

Redescription of *Myopsalta atrata* (Goding and Froggatt) and Description of Two New Species of *Myopsalta* Moulds (Hemiptera: Cicadidae) from Central Western New South Wales

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ABSTRACT. *Myopsalta atrata* (Goding & Froggatt) is redescribed in light of recently collected specimens that match the original type material. New evidence shows that *M. atrata* is restricted to the Hawkesbury Sandstone region, specifically in the vicinity of Greater Sydney in New South Wales, Australia. Two new species of *Myopsalta* are described from central western New South Wales: *Myopsalta libritor* sp.nov. and *M. coolahensis* sp.nov. Both occur in grassland, typically in association with alluvial terraces. In addition to morphological redescription, the species-specific calling song for each taxon is documented here for the first time.

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KEYWORDS. Cicadettini, Australia, *Melampsalta atrata*

Australia has a diverse cicada fauna, particularly in the tribe Cicadettini (Moulds, 2012). A large portion of this tribe is made up of small species (body length less than 20 mm). Many of these species occur in grass or small shrubs and are characterized by erratic seasonal emergences (Emery *et al.*, 2005). Since the adults are often highly mobile, inconspicuous and only persist for a few weeks at most, their capture is often serendipitous.

The genus *Myopsalta* Moulds was recently erected to accommodate eight Australian species (Moulds, 2012), with type species *Myopsalta crucifera* (Ashton, 1912). The name *Myopsalta atrata* (Goding and Froggatt, 1904) has

been associated with a species that is widespread in central eastern Australia (Emery *et al.*, 2005; Ewart, 1988, 1998; Moulds, 1990; Popple & Strange, 2002). New material has recently become available that corresponds more closely to the syntypes of *Myopsalta atrata* and places all other material previously treated as *M. atrata*, into uncertainty. Here we redescribe *M. atrata* based upon this new material and provide the first documentation of the calling song. The species previously referred to as *M. atrata* is now recognized as forming part of the *M. crucifera* species complex, a complex that requires substantial revision beyond the scope of the present study.

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Descriptions of two new species of *Myopsalta* from central NSW, along with details of the diagnostic characteristics of their calling songs, are also given here.

Methods and terminology

Anatomical terminology follows Moulds (2005, 2012) for body structures and wing characters, Moulds (2005) for genitalia, and Dugdale (1972) and Bennet-Clark (1977) for timbals. The long timbal ribs are referred to sequentially as long ribs numbered 1 to 5, with long rib 1 being the most posterior (adjacent to timbal plate). The higher classification adopted in this paper follows Moulds (2012). Measurements (in mm) are given as ranges with means in parentheses and include the largest and smallest specimens obtained. Head width spans across the outer margins of the compound eyes; pronotum width across the extremities of the lateral margins (excluding amplified lateral angles); abdominal width is measured across the outer edges of the auditory capsules.

Abbreviations: Material sourced for this taxonomic work is located in collections abbreviated as follows: *AM*, Australian Museum, Sydney; *ANIC*, Australian National Insect Collection, CSIRO, Canberra; *BMNH*, Natural History Museum, London, UK; *MM*, Macleay Museum, University of Sydney, Sydney; *DE*, private collection of D. L. Emery, Sydney; *MSM*, private collection of M. S. Moulds, Kuranda, Queensland; *LWP*, private collection of L. W. Popple, Brisbane.

Genitalia preparation: Male genitalia were removed using a pair of surgical scissors and placed in a solution of 10% potassium hydroxide. The solution was either boiled for one hour or left overnight at room temperature to clear the soft tissues and provide a clean dissection. Following clearing, the specimens were washed with ethanol and placed into a solution of either 70% ethanol or glycerol. To facilitate close examination of internal structures, the aedeagus was dissected for each genitalia preparation under 10x magnification.

All specimen measurements were taken using a pair of Supertool digital vernier calipers (accurate to 0.01 mm).

Calling song analysis. The general approach to describing the calling songs of these cicadas follows that of Ewart & Marques (2008). A “pulse” was defined as a single revolution of the timbals. The term “syllable” was used for the smallest grouping of pulses (typically 5–10 ms duration). When multiple syllables occur in succession, without coalescence (i.e. where the syllables are separated by short periods of silence), this was termed a “syllable sequence”. Where 2–9 syllables coalesce, this was referred to as a “macrosyllable”. Longer durations of continuous sound (≥ 10 syllables) were referred to as an “echeme”. For a repeated unit, comprising more than one of the above terms, the term “phrase” was adopted.

Field recordings have been used preferentially, when available. In cases where such recordings were not available, container recordings have been used. These latter recordings have a tendency to show distortion of the finer pulse structures of the songs and amplitude spectra due to reverberation. To address this problem, all recordings were carefully examined prior to analysis to select the cleanest and most natural representations available for comparative purposes.

Two different recording systems were used in this study. Each recording system (RS) is detailed as follows: (a) RS1: Tascam DR-07 digital recorder with an Audio-Technica

ATR-1655 cardioid condenser shotgun microphone, with recordings taken in the field by NJE; and (b) RS2: Sony MZR700 minidisc recorder with Sony ECM-MS957 Electret Condenser microphone, with recordings taken in the field by LWP.

Processing and analysis of recordings was undertaken with Cool Edit Pro (Version 2.1) software. Amplitude spectra were analysed in WaveShop (Version 1.0.14) software using a linear frequency axis on a 1024-point Fast Fourier Transform with a Hamming window function.

Systematics

Family Cicadidae Latrielle, 1802
Subfamily Cicadettinae Buckton, 1889
Tribe Cicadettini Buckton, 1889

Genus *Myopsalta* Moulds, 2012

Diagnosis. As documented in Moulds (2012), with a single, minor extension to accommodate the two new taxa described herein, as follows: *male genitalia*: endotheca exposed, soft, entirely fleshy (with the exception of *M. coolahensis* sp.nov. and *M. librator* sp.nov., which both possess a sclerotized endotheca).

Myopsalta atrata (Goding & Froggatt, 1904)

Figs 1–4

Melampsalta atrata Goding & Froggatt, 1904: 566, 638–639; Hahn, 1962, 8; Stevens & Carver, 1986: 264.

Notopsalta atrata.—Dugdale, 1972: 861, 864, fig. 23; Moulds, 2005: 395–397, 399, 417–419, 421, 425, figs 56–59, 62, table 1.

Myopsalta atrata.—Moulds, 2012: 18–21, 24, 151–154, table 1, fig. 28; Sanborn, 2014: 582–583, 798.

Not *Notopsalta atrata*.—Ewart, 1988: 183, 191, 194, 198–199, fig. 10A, plate 3F; Moulds, 1990: 160, 169, plate 19, figs 7, 7a; Ewart, 1998: 54–57, figs 1–2; Chambers *et al.*, 2001: 380; Popple & Strange, 2002: 22, 29, table 1; Emery *et al.*, 2005: 102–107, tables 1–3; Shiyake, 2007: 8, 108, 110, fig. 189.

Type material. Lectotype (hereby designated): 1♂, [handwritten] “Type/ *Melampsalta atrata*, G. & F. ♂ Australia” / [typeset] “on permanent loan from Macleay Museum, University of Sydney” (ANIC 32-007852). Paralectotype: 1♂, [handwritten] “*Melampsalta atrata*, God & Frogg, N. S. Wales/ *Melampsalta atrata*, Godg, type” / [typeset] “W.W. Froggatt collection” (ANIC 32-007858).

Other material examined: 1♂, Wises Track, Royal National Park, NSW, 34°06'59"S 151°03'30"E, 29.xi.2003, N. & D. Emery & L. Popple, recorded (LP); 1♂, same location, 13.ii.2005, S. & D. Emery; 6♂♂, same location, 14–25.x.2006, S., N. & D. Emery; 1♂, same location, 1.xi.2006, D. Emery; 15♂♂, same location, 20–28.x.2007, N. & D. Emery; 2♂, 1♀, same location, 31.x.2007, D. Emery; 2♂♂, same location, 20.x.2009, D. Emery; 3♂♂, same location, 1.xi.2009, N. & D. Emery; 1♂, same location, 20.xi.2011, N. & D. Emery; 6♂♂, Towlers Track, Ku-rin-gai Chase National Park, NSW, 33°37'33"S 151°16'39"E, 6.xi.2011, D. Emery; 1♂, Waratah Track, Ku-rin-gai Chase National Park, NSW, 33°38'12"S 151°15'05"E, 3.x.2012, D. Emery (all DE); 1♀, Goneria Ridge, Royal National Park, NSW, 28.ix.1969, G. Daniels (AM K307495).

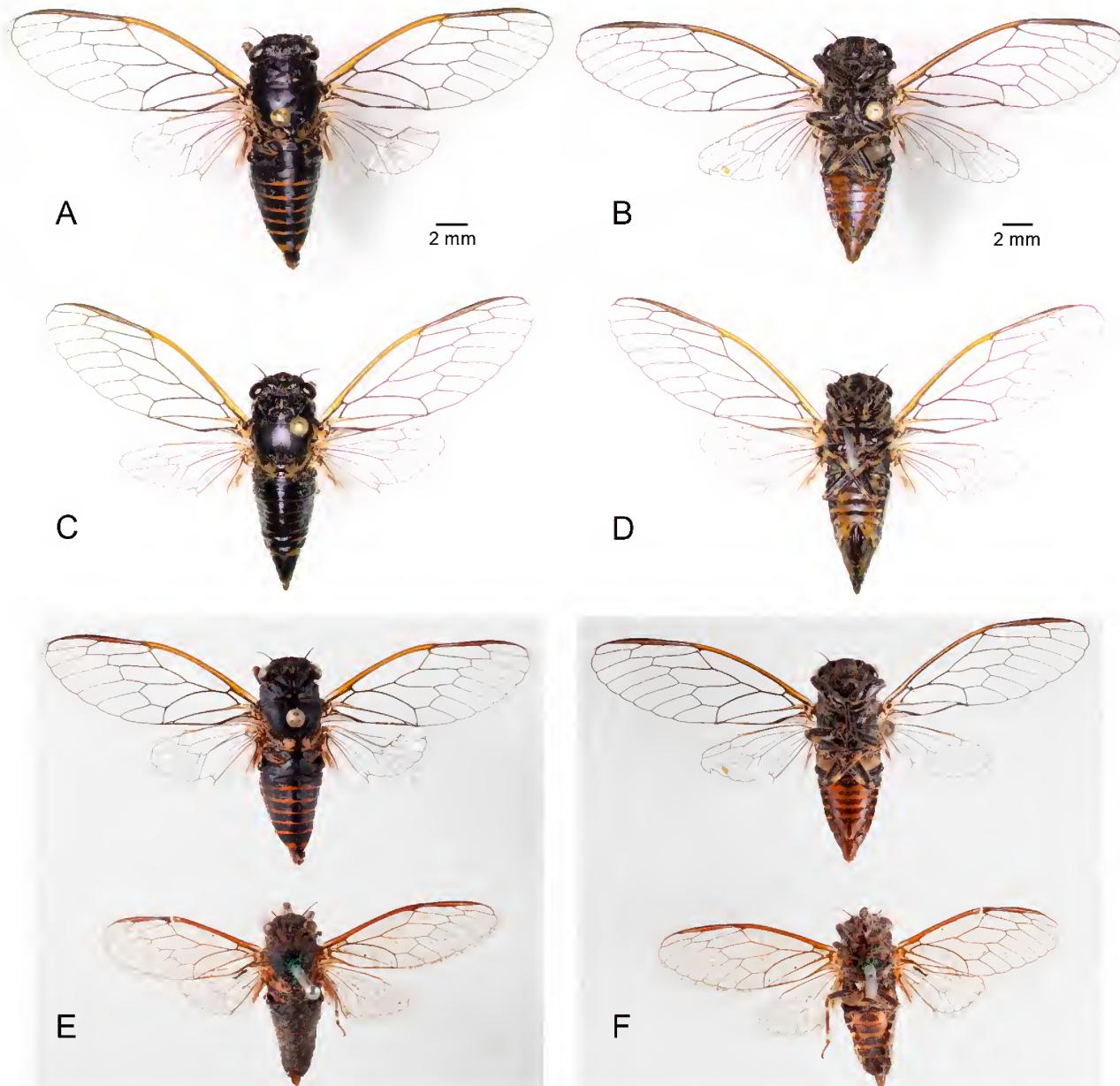


Figure 1. *Myopsalta atrata* (Goding & Froggatt). (A) male, Royal National Park ($34^{\circ}06'59"S$ $151^{\circ}03'30"E$), dorsal habitus; (B) male, ventral habitus; (C) female, Royal National Park, dorsal habitus; (D) female, ventral habitus; (E) comparison of dorsal habitus of Royal National Park ($34^{\circ}06'59"S$ $151^{\circ}03'30"E$) male (top) with lectotype male (New South Wales, ANIC) (bottom); (F) comparison of ventral habitus of Royal NP male (top) with lectotype male (bottom). A–F same scale.

Additional observations (audio recordings). NEW SOUTH WALES: Waratah track, Ku-ring-gai Chase National Park, $33^{\circ}38'13"S$ $151^{\circ}15'13"E$, 29.x.2011, B. Smith; Towlers Bay track, Ku-ring-gai Chase National Park, $33^{\circ}37'22"S$ $151^{\circ}16'13"E$, 5.xi.2011, B. Smith; Wisemans Ferry, $33^{\circ}23'03"S$ $150^{\circ}59'46"E$, 7.xi.2011, B. Smith; Bobbin Head, Ku-ring-gai Chase National Park, $33^{\circ}39'46"S$ $151^{\circ}09'40"E$, 30.ix.2013, B. Smith.

Description. Goding & Froggatt (1904, p. 639) described *Melampsalta atrata* from 3 males as: "Wholly black, with the following exceptions: an obsolete narrow middle stripe on pronotum, lateral and posterior borders of mesonotum and front side of tympana red; below black, chest red-lined; opercula broad, short, broadly rounded, black, the apical border solid yellow; basal segment of abdomen pale red; legs marked with red. Tegmina short, costal margin black; separated from radial vein, the space between and paracostal

marginal space red; the costa broadly rounded; veins red; interior ulnar vein and those surrounding basal area black; basal membranes red. Wings with venation reddish-black; interior vein of anal area broadly reddish-fuscous. Long. corp. 12 mm.; exp. teg. 30 mm."

The revised description, with first documentation of the female, is given below.

Male (Figs 1A–B, E–F, 2A).

Head including outer margins of eyes slightly wider than mesonotum; largely black, with small ochraceous triangular markings anterior and posterior to ocelli, apex directed anteriorly over postclypeus, ocelli red; postclypeus black, black transverse grooves, lateral margins ochraceous;

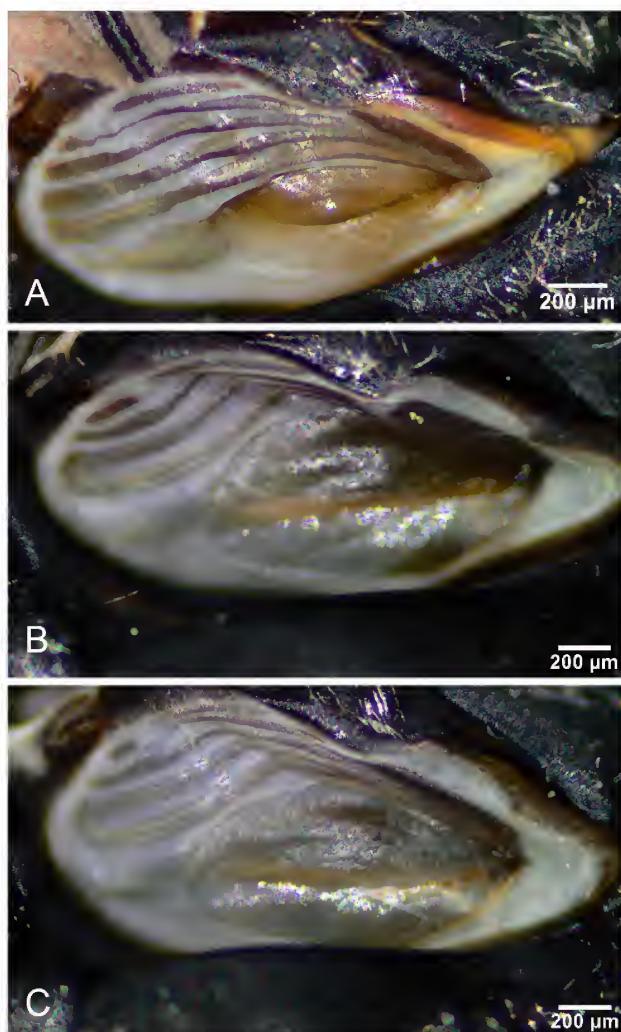


Figure 2. Photos of male left timbals, with dorsal edge at left and posterior margin at bottom: (A) *Myopsalta atrata* (Goding & Froggatt), Royal National Park (34°06'59"S 151°03'30"E); (B) *Myopsalta coolahensis* sp.nov., Coolah (31°56'25"S 149°52'18"E); (C) *Myopsalta libritor* sp.nov., Merriwa (32°08'19"S 150°21'00"E). Scale bars = 200 µm.

anteclypeus black; rostrum black, with length reaching midway between middle and posterior coxae; eyes black; antennae black, supra-antennal plates black.

Thorax mainly black. Pronotum black with anterior margin ochraceous, narrow central ochraceous stripe in middle third; pronotal collar shiny black with lateral margins rounded, wider than mesonotum. Mesonotum black; cruciform elevation wider than long, black with lateral ridges ochraceous, lateral depressions ochraceous; metanotum black, lighter along dorsal ridge, ochraceous posterior margin on midline.

Legs. Coxae black, with black lateral fascia; coxofemoral joints dull orange; femora variably striped black and ochraceous longitudinally; femoral primary spine black, erect; two smaller distal spines; femoro-tibial joints dull orange; tibiae ochraceous; spines on fore and mid legs black, translucent apically; tarsi ochraceous with black markings; fore claws black, mid and hind claws ochraceous with black tips.

Wings. Fore wing with 8 apical cells, costal veins ochraceous with black anterior margins, becoming black distally from the node; pterostigma mottled red-orange; basal cell translucent; forewings veins M and CuA fused before meeting basal cell, vein 2A+3A black, CuP+1A orange at base, fused posteriorly, other veins black at base, becoming ochraceous posteriorly; fore wing basal membranes translucent brown; hind wing plaga mottled orange-red medially, mottled black centrally, becoming hyaline posteriorly, with six apical cells.

Opercula prominent, spatulate, anterior half black, ochraceous and rounded posteriorly, clearly not meeting at base. Meracanthus small, black at base with edges and tip ochraceous, pointed, partly overlapping opercula.

Timbals (Fig. 2A) with five distinct long ribs; long ribs 1–3 brown dorsally, much paler ventrally and becoming lighter brown laterally, spanning across height of timbal; long rib 4 brown, narrowing medially in ventral half, long rib 5 brown, comparatively shorter; long ribs 1–3 fused dorsally along basal spur, separated ventrally; timbal dome brownish, extending over half width of timbal; apodeme pit oval-shaped, grey and small.

Abdomen slightly wider than thorax; tergite 1 black with posterior orange ridge, shorter than other tergites; tergite 2 completely black; tergites 3–7 black with intersegmental membranes orange; tergite 8 black, posterior and lateral areas orange. Sternite I black, sternites II–VIII orange with black mottling on anterior margins, more marked centrally, sternite VIII orange with whitish pubescence. Epipleurites 2–7 orange with black anterior margins.

Genitalia (Fig. 3). Pygofer orange-brown, dorsal beak brown, anal styles yellowish, extended as far as dorsal beak; upper lobe of pygofer less extended than dorsal beak, with apex rounded; basal lobe less produced than upper lobe, rounded with inner surface fused to pygofer. Uncus orange-brown, reddish posteriorly; in lateral view beak-like and stumpy; lobes in ventral view small, with tapered lateral termination, medial lobe small, ovoid; claspers with apices gradually tapering laterally to an acute termination. Aedeagus with pseudoparameres extending well beyond theca; endotheca short, stumpy, fleshy; ventral support terminating at apex of endotheca.

Female (Figs 1C–D).

Head including outer margins of eyes slightly wider than mesonotum; black, with thin ochraceous line along posterior half of midline extending to ocelli, small ochraceous triangular marking anterior to ocelli, apex directed anteriorly over postclypeus; ocelli pink-red; postclypeus black, ochraceous laterally and posteriorly, black transverse banding; anteclypeus black anteriorly, ochraceous posteriorly; rostrum black, with length reaching midway between middle and posterior coxae; eyes black; antennae black, supra-antennal plates black.

Thorax black with anterior margin ochraceous, narrow central ochraceous stripe in middle third; pronotal collar shiny black with lateral margins rounded, wider than mesonotum. Mesonotum black; cruciform elevation wider than long, black with lateral ridges ochraceous, lateral depressions ochraceous; metanotum ochraceous with black posterior ridges.

Legs with coxae black anteriorly, joint margins orange, with black lateral fascia; coxofemoral joints dull orange;

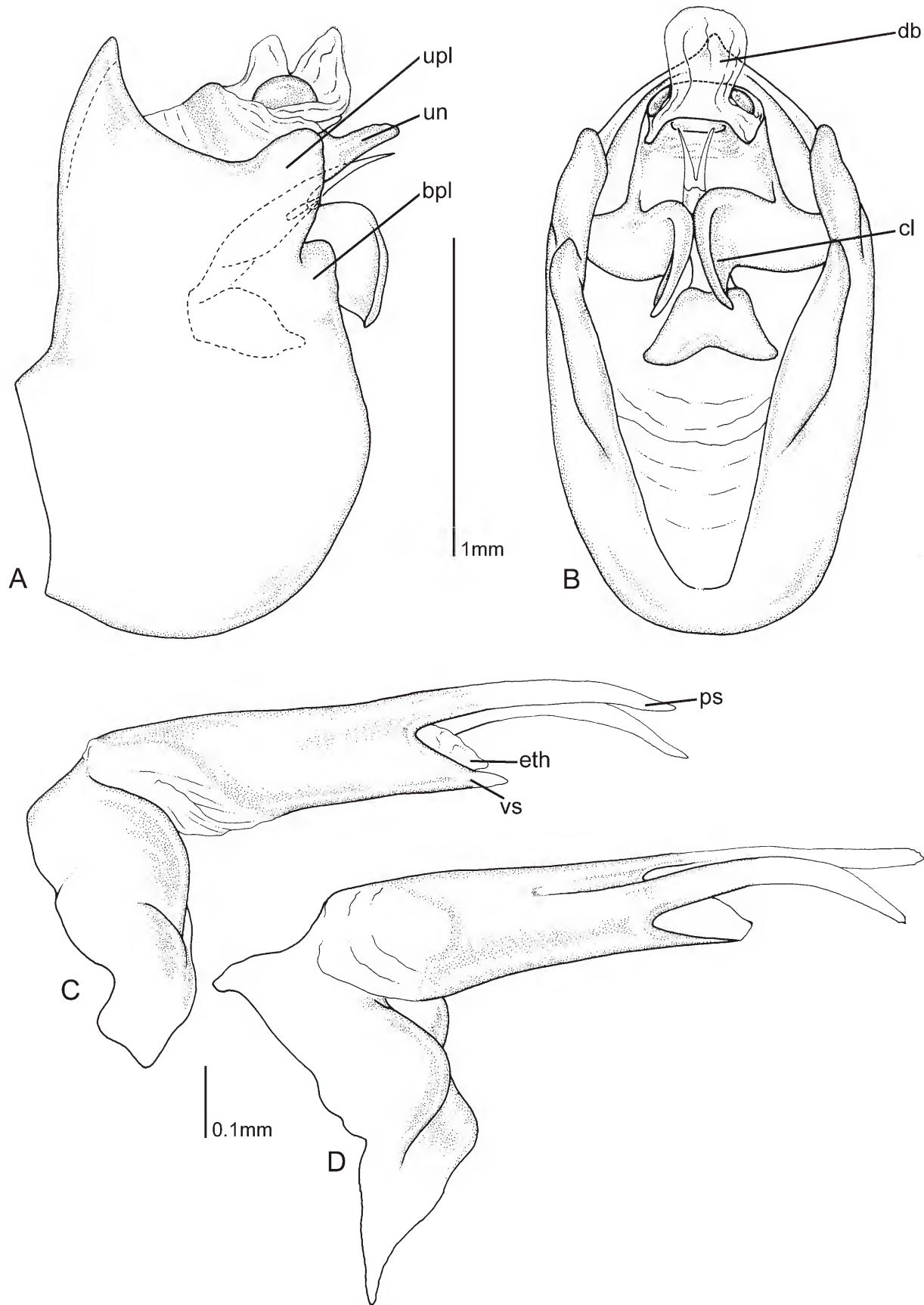


Figure 3. *Myopsalta atrata*—illustration of male pygofer and internal genitalia; (A) viewed laterally from the left; (B) viewed ventrally; (C) aedeagus, lateral view; and (D) aedeagus, rotated 30° left from central view C. Characters include: *aed*, aedeagus; *as*, anal style; *bpl*, basal lobe of pygofer; *cl*, clasper; *db*, dorsal beak; *eth*, endotheca; *ps*, pseudoparameres; *un*, uncus; *upl*, upper lobe of pygofer; *vs*, ventral support.

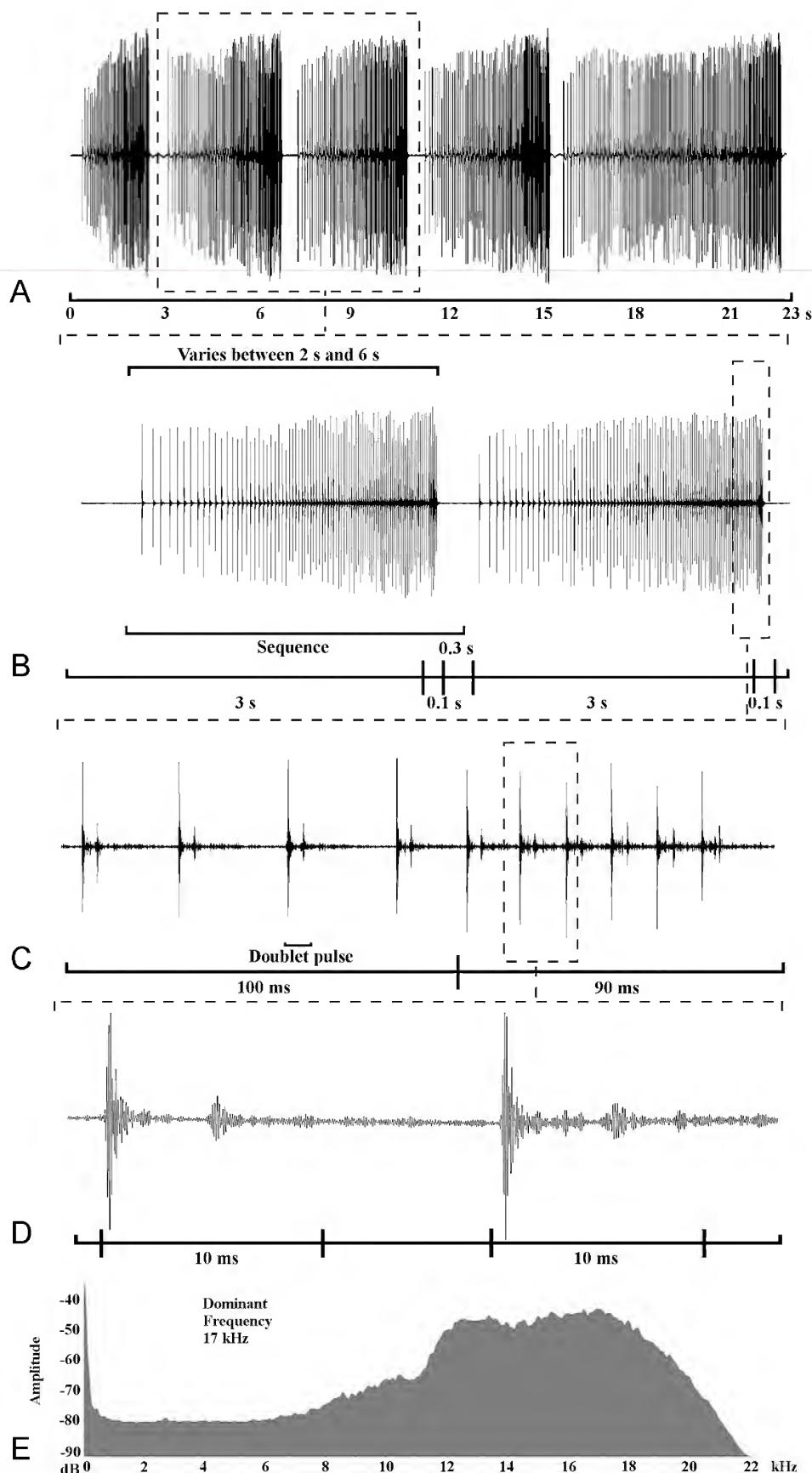


Figure 4. Male calling song structure of *Myopsalta atrata* (Goding & Froggatt) illustrated in waveform plot form. Each lower plot is expanded from the one above, to illustrate the finer temporal structure of each song component. The spectrogram at the bottom of the figure displays song frequency, which exhibits no modulation between the song components in this species. This specimen was recorded in the field by LWP at Royal National Park (34°06'59"S 151°03'30"E).

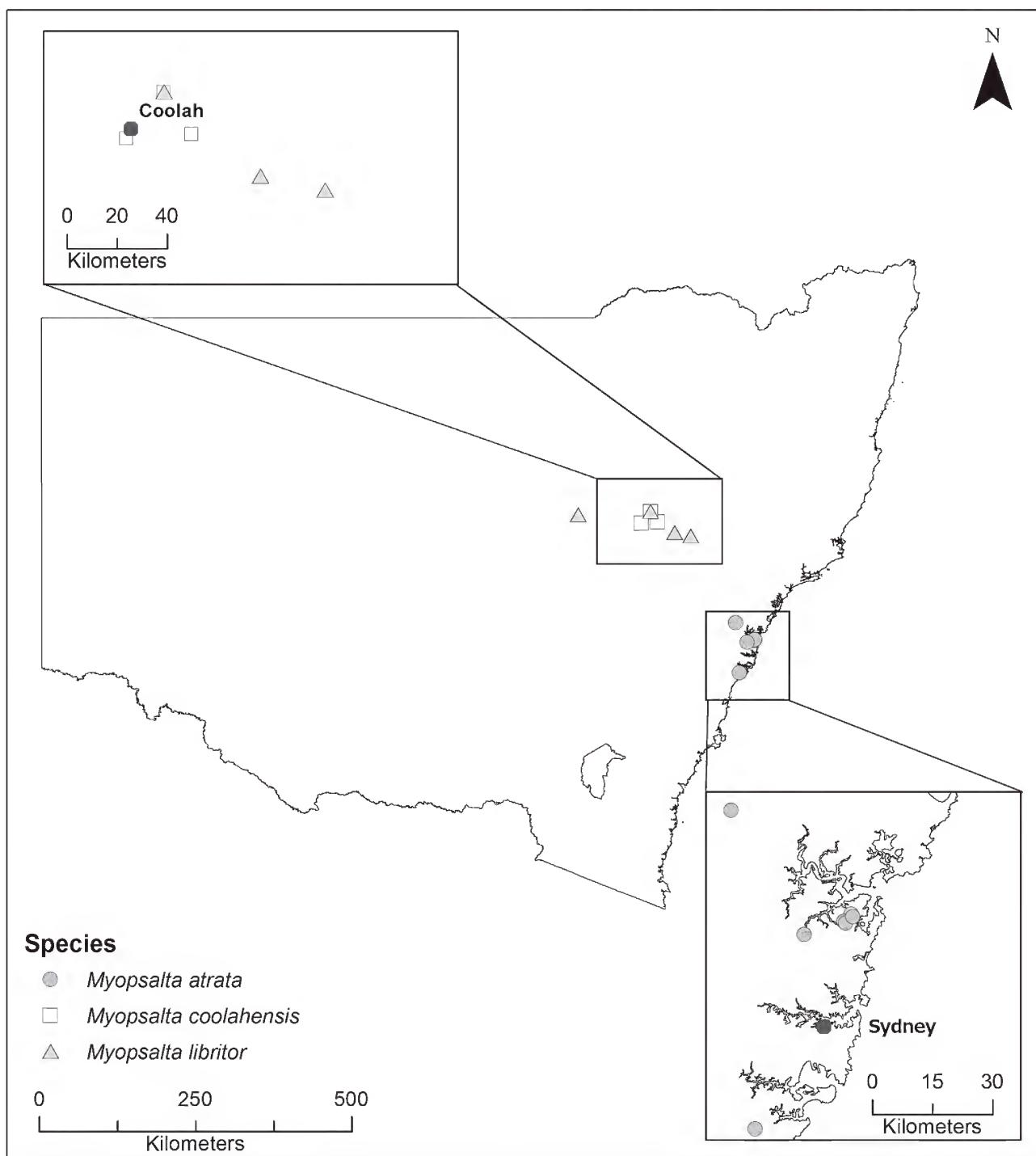


Figure 5. Map of eastern Australia showing the geographical distribution of *M. atrata* (closed circles), *M. coolahensis* sp.nov. (open squares) and *M. libitor* sp.nov. (closed triangles).

femora variably striped black and ochraceous longitudinally; femoral primary spine black, erect; femoro-tibial joints dull orange; tibiae ochraceous; spines on legs translucent to black; tarsi ochraceous with black markings; fore claws black, mid and hind claws ochraceous with black tips.

Wings with fore wing with 8 apical cells, costal veins ochraceous with black anterior margins, becoming black distally from the node; pterostigma mottled red-orange; basal cell clear; forewings veins M and CuA fused before meeting basal cell, vein 2A+3A black, CuP+1A orange at base, fused

posteriorly, other veins black at base, becoming ochraceous posteriorly; hind wing plaga mottled ochraceous, becoming brown clear posteriorly with bright orange posterior margin, six apical cells.

Abdomen as wide as thorax, with tergite 1 black with orange ridge curved posteriorly from anterior margin, shorter than other tergites, tergite 2 completely black, tergites 3–7 black with orange posterior margins extending to epipleurites, tergite 8 black anteriorly, posterior and lateral areas orange. Sternite I black, sternites II–VIII orange to

orange-brown with black mottling on anterior margins, most prominent medially. Abdominal segment 8 black centrally, ochraceous laterally, dorsal beak brownish. Epipleurites 2–7 orange with black anterior margins. Spiracles ochraceous. Ovipositor ochraceous-brown at base, becoming black at tip, extending up to 0.5 mm beyond posterior termination of abdomen.

Measurements (in mm; range with mean in parentheses; 10 males, 2 females). Body length: male 11.5–14.0 (12.9); female (incl. ovipositor) 15.2–15.3 (15.2). Fore wing length: male 13.5–16.2 (15.2); female 16.7–16.8 (16.7). Forewing width: male 5.0–5.8 (5.5); female 5.8–5.9 (5.9). Head width: male 3.9–4.5 (4.2); female 3.8–3.9 (3.9). Pronotum width: male 4.0–4.6 (4.3); female 4.2–4.3 (4.2). Abdomen width: male 4.1–4.7 (4.4); female 4.5–4.6 (4.6).

Distinguishing features. *Myopsalta atrata* can be distinguished from all other congeneric species by having conspicuous orange posterior tergite margins and predominantly orange to orange-brown sternites on all specimens (Fig. 1B,D,F). By comparison, other *Myopsalta* species have brown to black posterior tergite margins and pale brown to brown sternites with variable (i.e. weak to extensive) black markings (Figs 6B, 9B). Females can also be distinguished from other *Myopsalta* species by the length of the ovipositor sheath, which extends <0.5 mm beyond the apex of the abdomen. In contrast, ovipositors in females of other congeneric species extend >1 mm beyond the apex of the abdomen.

Calling song (Fig. 4). *Myopsalta atrata* has a fairly simple, repetitive call, with each phrase comprising a long initial syllable sequence of syllables (1.8–3.8 s total duration; all statistics, $n = 2$ recordings) followed by a much shorter, condensed syllable sequence or macrosyllable when coalesced (7–8 syllables, 0.06–0.085 s duration) (Fig. 4). The repetition rate of syllables in the initial syllable sequence begins at approximately 8 Hz and rapidly increases as the sequence progresses, reaching up to between 44 and 77 Hz

near the climax. A period of silence occurs at the end of each phrase, which may last from 400 ms to several seconds in duration. Close examination of the syllable structure reveals that each syllable actually comprises a single loud pulse, followed by a weaker echo, thought to represent the “in–out” buckling produced by a single action of the timbals.

The duration of each phrase ranges between 3 and 9 seconds. Available recordings indicate a highest amplitude frequency plateau between 12 and 18 kHz, and a dominant frequency of approximately 17 kHz (Fig. 4).

Distribution, habitat and behaviour. *Myopsalta atrata* is known only from coastal sandstone areas around Greater Sydney (part of the Hawkesbury Sandstone region) where populations occur in open heathland dominated by shrubs and small trees (Fig. 5). Cicadas typically emerge in early October and persist until early December. From 09:00–15:00 in sunlight, solitary males call briefly from the tops of small shrubs <1 m high before moving at regular intervals. From a similar height, females emit audible wing-flicks to attract males for courtship. It is not known whether this species is attracted to light.

Myopsalta coolahensis sp.nov.

Figs. 2B, 6–8

Type material. Holotype: ♂, 22 km S Coolah, [Australia] NSW, 31°56'25"S 149°52'18"E, 503 m, 14.xi.[20]13, N. & D. Emery (AM K447934). Paratypes: 2♂♂, 1♀, 22 km S Coolah, NSW, 31°56'25"S 149°52'18"E, 503 m, 13.xi.[20]13, N. & D. Emery; 8♂♂, same location, 14.xi.[20]13, N. & D. Emery; 4♂♂, 16♀♀, same location, 14.xi.[20]14, N. & D. Emery (recorded); 1♂, same location, 14.xii.[20]14, C. & D. Emery; 2♂♂, same location, 16.ii.[20]15, N. & D. Emery; 7♂♂, 5 km E Coolah, NSW, 31°47'17"S 149°46'27"E, 521 m, 14.xi.[20]13, N. & D. Emery; 2♂♂, Black Stump Rd, 15 km SW Coolah, NSW, 31°57'17"S 149°38'38"E, 420 m, 14.xi.[20]14, N. & D. Emery (all DE); 2♂♂, 22 km S Coolah, NSW, 31°56'25"S 149°52'18"E, 503 m, 13.xi.[20]13, N. & D. Emery; 1♂, 2♀♀, 22 km S Coolah, NSW, 503 m, 31°56'25"S 149°52'18"E, N. & D. Emery (all LWP); 1♀, 22 km S Coolah, NSW, 31°56'25"S 149°52'18"E, 503 m, 13.xi.[20]13, N. & D. Emery (AM K447935).

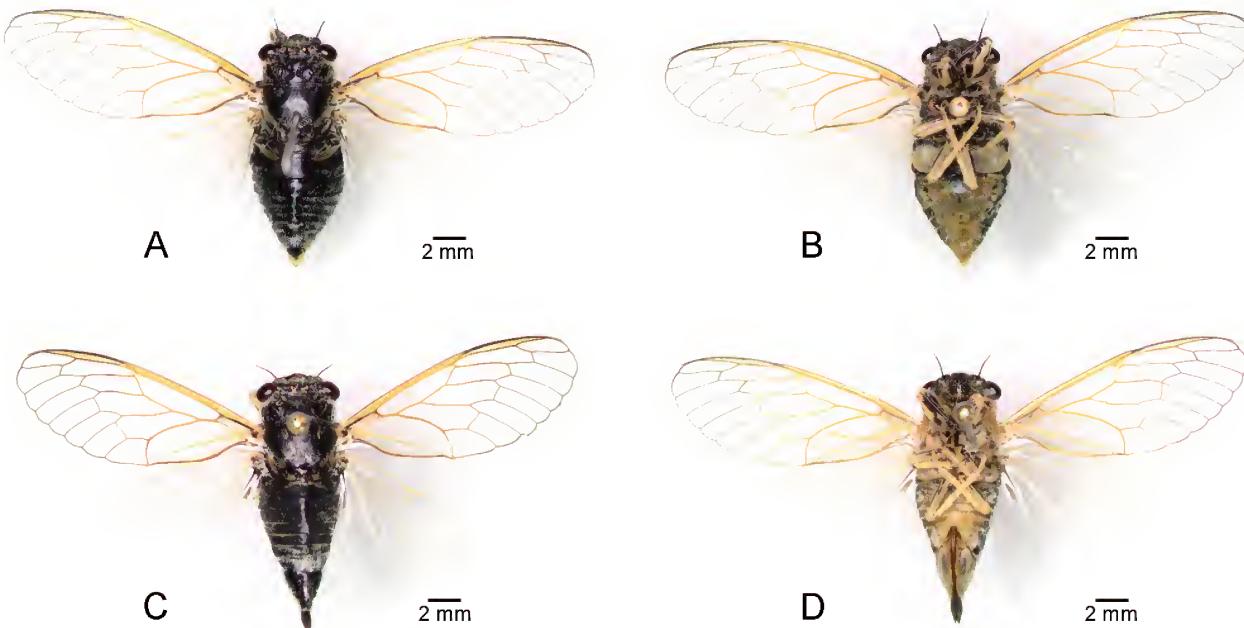


Figure 6. *Myopsalta coolahensis* sp.nov. (A) male, Coolah (31°56'25"S 149°52'18"E), dorsal habitus; (B) male, Coolah, ventral habitus; (C) female, Coolah, dorsal habitus; (D) female, Coolah, ventral habitus. Scale bars = 2 mm.

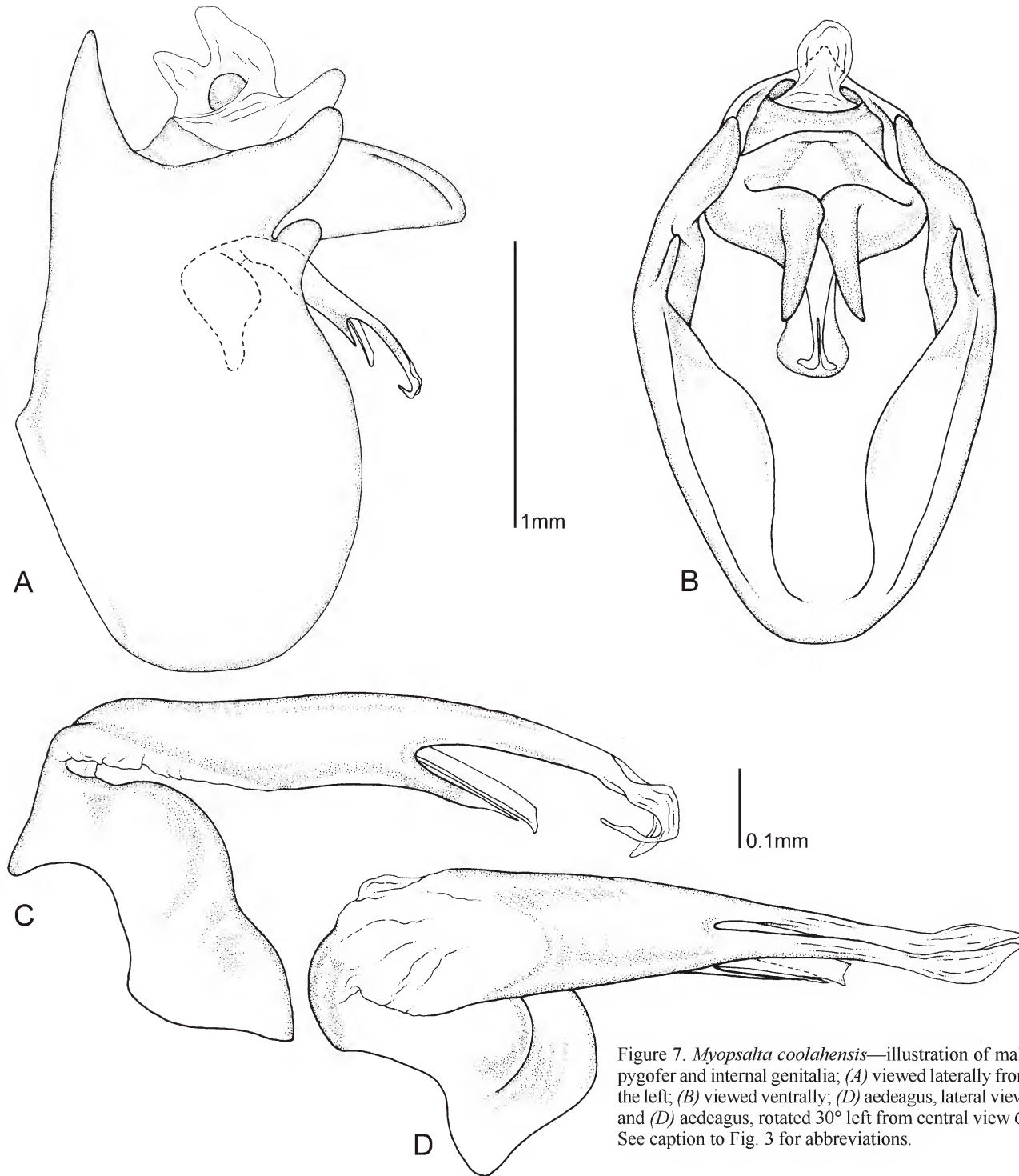


Figure 7. *Myopsalta coolahensis*—illustration of male pygofer and internal genitalia; (A) viewed laterally from the left; (B) viewed ventrally; (C) aedeagus, lateral view; and (D) aedeagus, rotated 30° left from central view C. See caption to Fig. 3 for abbreviations.

Etymology. The name is based on the locality where this species has been found—the Coolah region of New South Wales.

Description. Male (Figs 2B, 6A–B). *Head* including outer margins of eyes slightly wider than mesonotum; largely black, with ochraceous triangular marking anterior to ocelli, apex directed anteriorly over postclypeus, ocelli pink to clear; postclypeus black centrally sometimes with central narrow longitudinal ochraceous line extending ventrally along medial surface, black transverse grooves,

lateral margins ochraceous; anteclypeus shiny black; rostrum black, with length almost reaching anterior edge of posterior coxae; eyes black; antennae black, supra-antennal plates black.

Thorax mainly black. Pronotum black; pronotal collar shiny black with lateral margins rounded, wider than mesonotum. Mesonotum black; cruciform elevation black, lateral posterior margin variably ochraceous; metanotum black, lighter along dorsal ridge.

Legs with coxae striped black and ochraceous longitudinally, with black lateral fascia; femora also variably

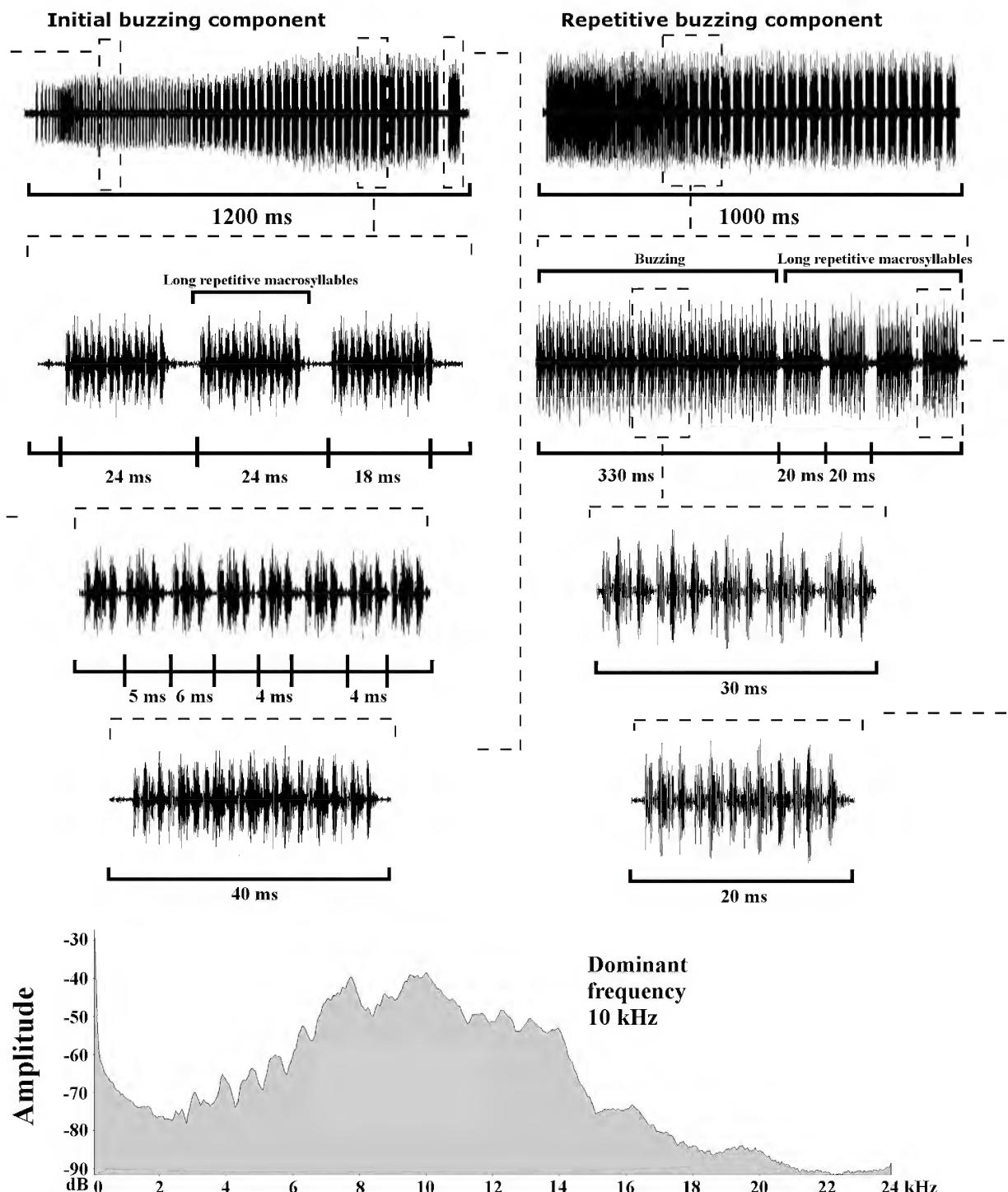


Figure 8. Male calling song structures of *Myopsalta coolahensis* sp.nov., illustrated in waveform plot form. Each lower plot is expanded from the one above, to illustrate the finer temporal structure of each song component. The spectrogram at the bottom of the figure displays song frequency, which exhibits no modulation between the song components in this species. This specimen was recorded by NJE in the field near Coolah (31°56'25"S 149°52'18"E) at 10h30 on 14 November 2014.

striped black and ochraceous longitudinally, fore leg spines black, erect; fore tibia black, mid and hind tibiae ochraceous; spines on hind legs translucent to brown; tarsi ochraceous becoming black at claws; claws black.

Wings with fore wing costal veins ochraceous with black anterior margins, becoming black distally from the node; basal membranes white; forewings veins M and CuA fused before meeting basal cell, vein 2A+3A black, other

veins black at base, becoming ochraceous posteriorly; hind wing plaga white, mottled black centrally, becoming clear posteriorly, anal cell 2 variably mottled black anteriorly, becoming clear posteriorly, with six apical cells.

Opercula prominent, spatulate, anterior half black, ochraceous over remainder and rounded posteriorly, almost meeting at base. Meracanthus small, black at base with edges and tip ochraceous, pointed, not overlapping opercula.

Timbals (Fig. 2B) with five distinct long ribs; long ribs 1–3 brown to black dorsally, much paler ventrally and becoming identical in colour to surrounding grey membrane, spanning entire height of timbal; long rib 4 brown, discontinuous, with an isolated ventral section; long rib 5 brown, comparatively shorter; long ribs 1–3 fused dorsally along basal spur; timbal dome translucent, extending over half width of timbal; apodeme pit oval-shaped, grey and conspicuous.

Abdomen with tergites 1 to 6 black, tergite 1 shorter than other tergites, with distinct grey u-shaped marking on lateral edge, directed posteriorly; tergite 2 black; tergites 3–7 black, posterior margins grey laterally, tergite 8 black, posterior and lateral areas ochraceous. Sternite I black, pale brown laterally; sternite II black with lateral posterior margin mottled pale brown; Sternite III pale brown with variable central black marking; sternites IV–VIII pale brown to lurid; sternite IX pale brown with white pubescence, extending beyond dorsal beak.

Genitalia (Fig. 7). Pygofer black dorsally, ochraceous laterally, dorsal beak black, anal styles yellowish, extended beyond dorsal beak; upper lobe of pygofer extended as far as dorsal beak, with apex acute, rounded at tip; basal lobe more produced than upper lobe, very rounded. Uncus ochraceous; in lateral view beak-like and stumpy; in ventral view tapered at lateral termination; claspers with apices gradually tapering laterally to an acute termination. Aedeagus with pseudoparameres extending well beyond theca; endotheca sclerotized, extending beyond ventral support, apex fairly blunt.

Female (Fig. 6C–D).

Head, thorax and dorsal abdomen similar to male. Abdominal segment 9 black, lateral areas ochraceous with black spot, dorsal beak black with posterior edges ochraceous. Sternite I pale, sternite II pale, black centrally with lateral areas ochraceous, sternites III–VII ochraceous, sternite VIII ochraceous with prominent lateral black spot, white pubescence. Abdominal segment 9 ochraceous with central diffuse ovoid darker coloration parallel to ovipositor. Ovipositor brown at base, becoming black at tip, extending 1.5 mm past body.

Measurements (in mm; range with mean in parentheses; 12 males, 12 females). Body length: male 12.0–14.2 (13.3); female (incl. ovipositor) 14.0–15.2 (14.7). Fore wing length: male 14.3–16.3 (15.4); female 15.1–16.8 (15.7). Forewing width: male 5.8–6.9 (6.4); female 5.4–6.1 (5.8). Head width: male 4.5–5.0 (4.8); female 4.5–5.0 (4.7). Pronotum width: male 3.9–4.9 (4.8); female 4.0–4.6 (4.3). Abdomen width: male 5.4–6.6 (6.2); female 4.4–5.5 (5.0).

Distinguishing features. *Myopsalta coolahensis* sp.nov. can be distinguished from *M. binotata* (Goding & Froggatt), *M. lactea* (Distant) and *M. waterhousei* (Distant) by its lack of forewing infuscations. Its black dorsal coloration distinguishes it from *M. crucifera* (Ashton) and *M. mackinlayi* (Distant), which are both predominantly brown. Female specimens of *M. coolahensis* do not possess the orange to orange-brown sternite coloration of *M. atrata*, instead they are pale brown. Specimens of *M. coolahensis* sp.nov. can be distinguished from *M. librator* sp.nov. by the absence of central black markings on sternites, present in the latter species. *M. coolahensis* can be distinguished from specimens of *M. wollomombii* by two main features:

it possesses (1) a head width ≥ 4.5 mm, and (2) a ventral thorax that is extensively blackened; *M. wollomombii* has a head width < 4.3 mm and the ventral thorax is pale brown (Coombs, 1995).

Calling song (Fig. 8). The call of this species features two components, an initial buzzing component and a repetitive buzzing component (Fig. 8). The initial buzzing component comprising a series of syllables (each being 4 milliseconds (ms) duration, three pulses; all statistics based on $n = 1$ recording), followed by a series of macrosyllables (each being 18–24 ms duration). This component ends with a final longer macrosyllable ranging between 34 and 40 ms duration. A period of silence between 75 and 78 ms duration occurs between multiple callings of this initial buzzing component. The duration of this component ranges between 1,280 and 1,500 ms.

The repetitive buzzing component comprises an echeme that ranges between 340 and 375 ms duration. This is followed by a (macro)syllable sequence ranging between 650 and 670 ms duration (comprising between 24 and 26 macrosyllables, each 19 to 21 ms duration, $n = 1$). A period of silence between 13 and 20 ms duration separates each of the macrosyllables.

The single recording indicates a highest amplitude frequency plateau between 9 and 11 kHz, and a dominant frequency of 10 kHz (Fig. 8). Some components of the song extend down to around 7.5 kHz.

Distribution, habitat and behaviour. Known only from three populations around Coolah, NSW (Fig. 5). The populations were located amongst roadside plants and grass < 1 m in height and in adjacent paddocks, usually around half-way up the stalks. They were found to particularly favour wild oat grass (*Avena fatua*). All locations were flat, low-lying areas within 500 m of watercourses, particularly close to the Talbragar and Coolaburragundy rivers. These areas may provide more reliable food sources than surrounding areas, as the cicadas were not found on similar vegetation on local slopes and hills. Males were observed to become more wary with increasing temperature unless a female was present; they typically fly < 5 m. This species ceases calling when wind gusts exceed 15 kmh.

Myopsalta librator sp.nov.

Figs. 2C, 9–11

Type material. Holotype: ♂, 5 km E Coolah NSW, 31°47'17"S 149°46'27"E, 521 m, 13.xi.13, N. & D. Emery (AM K447936). Paratypes: 4♂♂, 5 km E Coolah NSW, 31°47'17"S 149°46'27"E, 521 m, 13.xi.13, N. & D. Emery; 2♂♂, same location, 14.xi.14, N. & D. Emery; 1♂, Merriwa, NSW, 32°08'19"S 150°21'00"E, 244 m, 16.i.14, S. Emery & T. Corbin; 6♂♂, 2♀♀, same location, 14.xi.14, N. & D. Emery (recorded); 4♂♂, 1♀, 1 km S. Coolah, NSW, 31°49'44"S 148°43'43"E, 520 m, 14.x.14, N. C. & D. Emery; 3♂♂, Junction of Golden Highway and Krui River, 32°05'48"S; 150°07'07"E, 14.xi.14, N. & D. Emery (all DE); 1♂, 5 km E Coolah NSW, 31°47'17"S 149°46'27"E, 521 m, 13.xi.13, N. & D. Emery; 1♂, 1♀, Australia NSW, Merriwa, 32°08'19"S 150°21'00"E, 244 m, 14.xi.2014, N. & D. Emery (both LWP); 1♀, 5 km E Coolah NSW, 31°47'17"S 149°46'27"E, 521 m, 13.xi.13, N. & D. Emery (AM K447937).

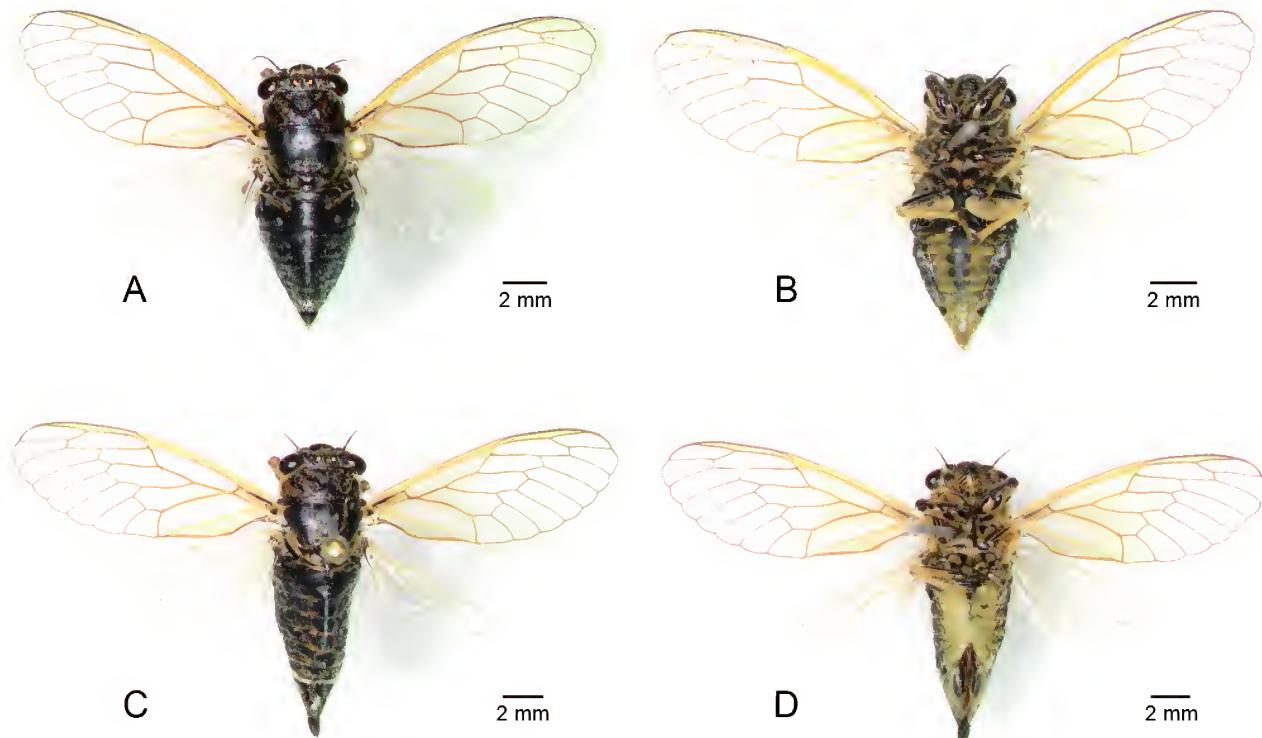


Figure 9. *Myopsalta libritor* sp.nov. (A) male, Coolah (31°47'17"S 149°46'27"E), dorsal habitus; (B) male, Coolah, ventral habitus; (C) female, Merriwa (32°08'19"S 150°21'00"E), dorsal habitus; (D) female, Merriwa, ventral habitus. Scale bars = 2 mm.

Etymology. The Latin word *libritor* (masculine) is presented in its original form as a noun in apposition. It is defined as a hurler, thrower or gunner and is a reference to the machine gun-like sound of the calling song of this cicada.

Description. Male (Figs 2C, 9A–B). *Head* including outer margins of eyes slightly wider than mesonotum; black, with olivaceous triangular marking anterior to ocelli, apex directed anteriorly over postclypeus; ocelli pink to red; postclypeus entirely black; anteclypeus shiny black; rostrum black, with length almost reaching anterior edge of posterior coxae; eyes black; antennae black, supra-antennal plates black.

Thorax mainly black. Pronotum black; pronotal collar shiny black with lateral margins rounded, wider than mesonotum. Mesonotum black; cruciform elevation black; metanotum black.

Legs. Coxae black, thin ochraceous stripe on lateral edge, with black lateral fascia; femora black with two ochraceous longitudinal stripes, femoral spines black, erect; femoral joint ochraceous; fore tibia black; mid tibia ochraceous with thin posterior black stripe, hind tibia ochraceous with proximal black spot, spines on hind tibia pale brown to translucent; fore tarsi black, mid and hind tarsi ochraceous; claws black.

Wings with fore wing costal veins ochraceous, becoming black distally from the node, subcostal vein black; basal membranes translucent; forewings veins M and CuA fused before meeting basal cell, vein 2A+3A black, other veins black at base, becoming ochraceous posteriorly; hind wing plaga white, mottled black centrally, becoming clear posteriorly, white plaga along veins 2A and 3A, anal cell 2 variably mottled black anteriorly, becoming clear posteriorly, with six apical cells.

Opercula prominent, following body axis lateroventrally,

broadly sickle-shaped rounded posteriorly, ochraceous, black at base; clearly separated. Meracanthus small, black at base with lateral edges ochraceous to tip, narrow, pointed, not overlapping opercula.

Timbals (Fig. 2C) with five distinct long ribs; long ribs 1–3 brown to black dorsally, much paler ventrally and becoming identical in colour to surrounding grey membrane, spanning height of timbal; long rib 4 grey-brown, discontinuous, with an isolated ventral extension; long rib 5 grey brown, comparatively shorter; long ribs 1–3 fused dorsally along basal spur; timbal dome opaque, extending over half width of timbale, grooved diagonally; apodeme pit oval-shaped, grey-black and conspicuous.

Abdomen with tergites 1 to 7 black, tergite 1 shorter than other tergites, tergite 8 black, posterior and lateral areas dark ochraceous. Sternite I black, sternite II black with lateral posterior margin pale brown, sternite III pale brown, with a black spot in each lateral depression, and a prominent black marking on midline, sometimes reducing posteriorly, sternites IV–VII pale brown with a prominent black midline and dark translucent lateral margins; sternites VIII and IX pale brown with white pubescence.

Genitalia (Fig. 10). Pygofer black dorsally, ochraceous laterally, dorsal beak black, anal styles yellow, not extended as far as dorsal beak; upper lobe of pygofer extended almost as far as dorsal beak, with apex rounded at tip; basal lobe not produced, very rounded. Uncus black laterally, medial lobe yellow, in lateral view beak-like and stumpy, in ventral view tapered at lateral termination; claspers with apices gradually tapering laterally to an acute termination. Aedeagus with pseudoparameres extending well beyond theca; endotheca sclerotized, extending beyond ventral support, apex smooth.

Female (Fig. 9C,D).

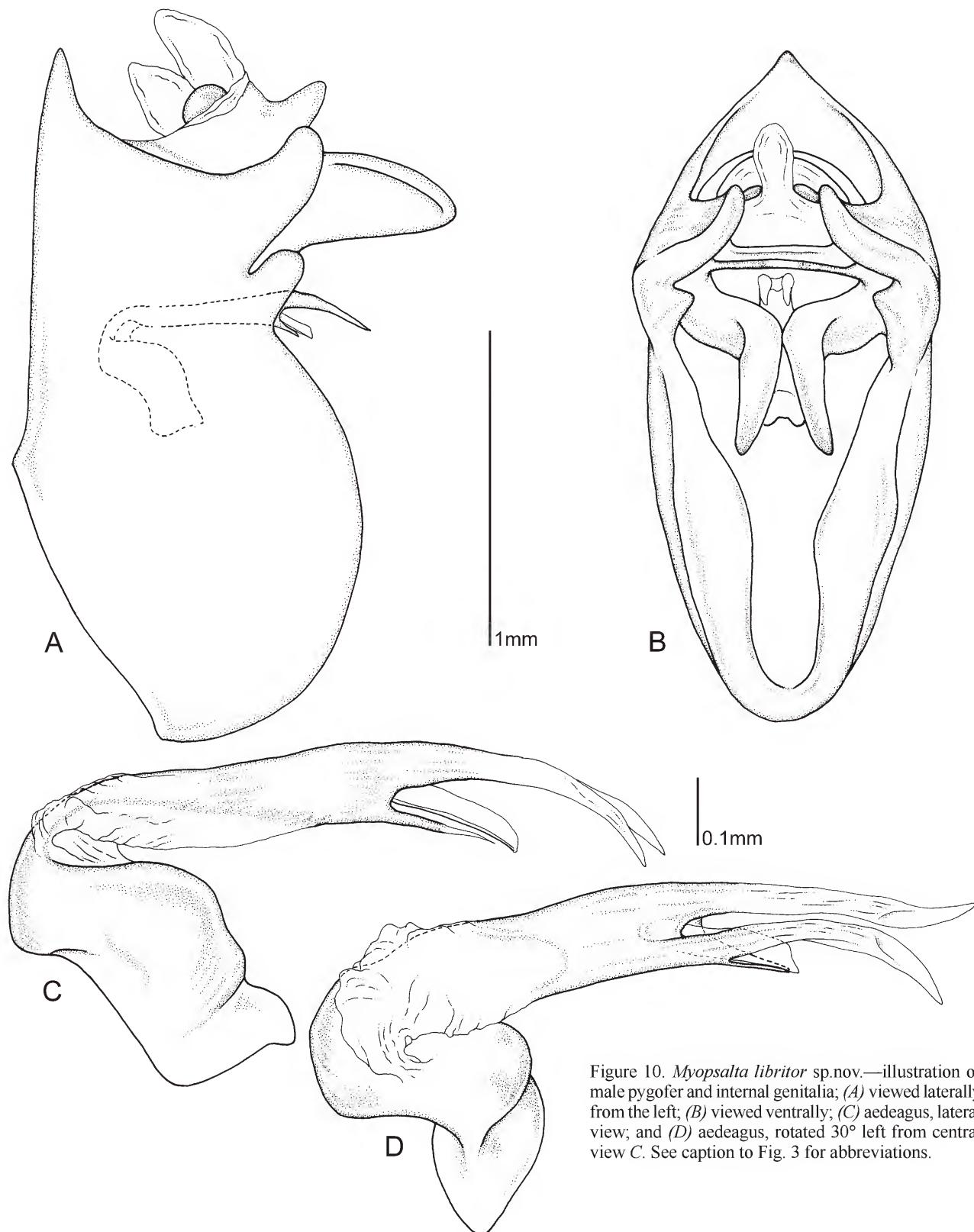


Figure 10. *Myopsalta libitor* sp.nov.—illustration of male pygofer and internal genitalia; (A) viewed laterally from the left; (B) viewed ventrally; (C) aedeagus, lateral view; and (D) aedeagus, rotated 30° left from central view C. See caption to Fig. 3 for abbreviations.

Head including outer margins of eyes slightly wider than mesonotum; black, ochraceous triangular marking anterior to ocelli, apex directed anteriorly over postclypeus, ocelli red; postclypeus entirely black; anteclypeus shiny black; rostrum black, with length almost reaching anterior edge of posterior coxae; eyes black; antennae black, supra-antennal plates black.

Thorax black; pronotal collar black with lateral margins ochraceous, rounded, wider than mesonotum. Mesonotum black; cruciform elevation black, lateral depression ochraceous posteriorly; metanotum black with ochraceous ridges.

Legs with anterior and posterior coxae black, joints black, remainder ochraceous anterior; femora striped black-

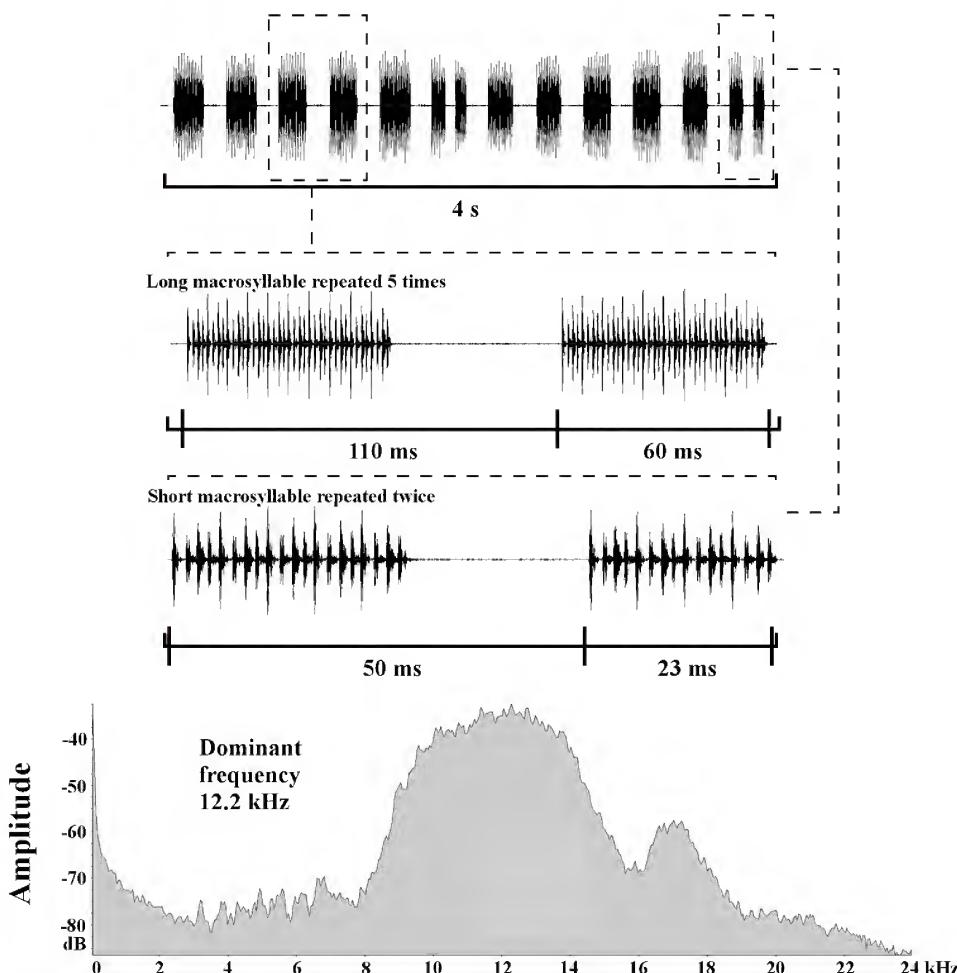


Figure 11. Male calling song structure of *Myopsalta libritor* sp.nov., illustrated in waveform plot form. Each lower plot is expanded from the one above, to illustrate the finer temporal structure of each song comparison. The spectrogram at the bottom of the figure displays song frequency. The specimen was recorded in grass by NJE at Merriwa (32°08'19"S 150°21'00"E) at 09h00 on 14 November 2014.

ochraceous, femoral joint ochraceous; fore tibia black; mid and hind tibiae black; spines on fore and mid legs translucent with black tips; tarsi black; claws black.

Wings with fore wing costal veins ochraceous, becoming black distally from the node, subcostal vein black; basal membranes translucent; forewings veins M and CuA fused before meeting basal cell, vein 2A+3A black, other veins black at base, becoming ochraceous posteriorly; hind wing plaga white along veins 2A and 3A, mottled black centrally, becoming clear posteriorly; with six apical cells.

Abdomen with tergites 1 to 7 black, posterior margins ochraceous, becoming more pronounced laterally, tergite 1 shorter than other tergites, tergite 8 black, posterior and lateral areas ochraceous. Sternite I black; sternite II black with lateral posterior margin pale brown; sternites III–VII pale brown, pale orange on posterior margins, with central black markings decreasing posteriorly to sternite VI; gonocoxite VIII pale brown with white pubescence. Abdominal segment 9 black, pale brown laterally with black stigma; dorsal beak black. Ovipositor ochraceous-brown at base, becoming black at tip, extending 1 mm past body.

Measurements (in mm; range with mean in parentheses; 12 males, 4 females). Body length: male 11.3–12.6 (11.9); female (incl. ovipositor) 13.9–15.0 (14.6). Fore wing length: male 12.3–14.4 (13.4); female 13.9–16.5 (15.2). Forewing

width: male 4.9–6.2 (5.4); female 5.7–6.0 (5.9). Head width: male 3.9–4.2 (4.1); female 4.5–4.9 (4.7). Pronotum width: male 3.8–4.2 (4.0); female 4.0–4.5 (4.3). Abdomen width: male 4.3–5.3 (5.0); female 4.4–4.6 (4.5).

Distinguishing features. *Myopsalta libritor* sp.nov. can be distinguished from *M. binotata* (Goding & Froggatt), *M. lactea* (Distant) and *M. waterhousei* (Distant) by lacking fore wing infuscations. The predominantly black dorsal coloration of *M. libritor* distinguishes it from *M. crucifera* (Ashton) and *M. mackinlayi* (Distant), which are mainly brown above. The female specimens of *M. libritor* sp.nov. do not possess the dominantly orange-brown sternite coloration of *M. atrata*. Specimens of *M. libritor* sp.nov. can be distinguished from *M. wollomombii* and *M. coolahensis* sp.nov. by the presence of central black markings that are absent on the sternites of the latter two species.

Calling song (Fig. 11). This species has a simple repetitive call that comprises a series of long macrosyllables and culminates in a pair of shorter macrosyllables (Figure 11). Each long macrosyllable is between 57 and 66 milliseconds (ms) in duration (each contains between 10 and 12 syllables; all statistics $n = 1$ recording). A short period of silence between 50 and 55 ms duration occurs between each long macrosyllable.

Each short macrosyllable is between 25 and 30 ms duration, and comprises between 8 and 10 syllables. A short period of silence between 50 and 55 ms duration occurs between each short macrosyllable.

The single recording indicates a highest amplitude frequency plateau between 10 and 14 kHz, and a dominant frequency of 12.2 kHz (Fig. 11). A secondary small peak between 16 and 18 kHz is also associated with the call of this species.

Distribution, habitat and behaviour. Known from around Coolah and 80 km SE to Merriwa, NSW, close to the Coolaburragundy, Krui and Merriwa rivers (Fig. 5). Cicadas were located around the upper third of roadside plants and grass <1 m, and in adjacent paddocks and parks that were close to perennial watercourses. Cicadas were absent from similar vegetation on local creeks, slopes and hills. Males were most active in direct sunlight and flew <5 m between singing sites. When wind gusts increased above 15 km/h, cicadas ceased singing and moved towards the base of plants. Depending on the season, cicadas emerged in mid-October and could persist until mid-January.

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References

Bennet-Clark, H. 1997. Tymbal mechanics and the control of song frequency in the cicada *Cyclochila australasiae*. *Journal of Experimental Biology* 200 (11): 1681–1694.

Chambers, G. K., W. M. Boon, T. R. Buckley, and R. A. Hitchmough. 2001. Using molecular methods to understand the Gondwana affinities of the New Zealand biota: three case studies. *Australian Journal of Botany* 49 (3): 377–387. <http://dx.doi.org/10.1071/BT00021>

Coombs, M., 1995. A new species of *Urabunana* (Distant) and new locality records for *U. marshalli* (Distant) (Hemiptera: Cicadidae) from northern New South Wales. *Journal of the Australian entomological Society* 34(1): 13–15. <http://dx.doi.org/10.1111/j.1440-6055.1995.tb01266.x>

Duggdale, J. 1972. Genera of New Zealand Cicadidae (Homoptera). *New Zealand Journal of Science* 14(4): 856–882.

Emery, D. L., S. J. Emery, N. J. Emery, and L. W. Popple. 2005. A phenological study of the cicadas (Hemiptera; Cicadidae) in western Sydney, New South Wales, with notes on plant associations. *Australian Entomologist* 32(1): 92–101.

Ewart, A., and D. Marques. 2008. A new genus of grass cicadas (Hemiptera: Cicadoidea: Cicadidae) from Queensland, with descriptions of their songs. *Memoirs of the Queensland Museum* 52(2): 149–202.

Goding, F. W., and W. W. Froggatt. 1904. Monograph of the Australian Cicadidae. *Proceedings of the Linnean Society of New South Wales* 29(3): 561–670.

Hahn, D. E. 1962. *A List of the Designated Type Specimens in the Macleay Museum. INSECTA*. Sydney, Australia: The Macleay Museum (The University of Sydney), 184 pp.

Moulds, M. S. 1990. *Australian Cicadas*. Kensington, Australia: New South Wales University Press, 169 pp.

Moulds, M. S. 2005. An appraisal of the higher classification of cicadas (Hemiptera: Cicadoidea) with special reference to the Australian fauna. *Records of the Australian Museum* 57(3): 375–446. <http://dx.doi.org/10.3853/j.0067-1975.57.2005.1447>

Moulds, M. S. 2012. A review of the genera of Australian cicadas (Hemiptera: Cicadoidea). *Zootaxa* 3287(1): 1–262.

Moulds, M. S., and S. A. Cowan. 2002. Cicadoidea. In *Zoological Catalogue of Australia*. Canberra: Australian Biological Resources Study, 55 pp.

Popple, L. W., and A. D. Strange. 2002. Cicadas, and their songs, from the Tara and Waroo Shires, southern central Queensland. *Queensland Naturalist* 22(1): 15–30.

Sanborn, A. 2014. *Catalogue of the Cicadoidea (Hemiptera: Auchenorrhyncha)*. London: Academic Press/Elsevier, 1001 pp.

Shiyanke, S. 2007. *World Cicadas 200*. Osaka: Osaka Museum of Natural History, 126 pp.

Stevens, M. M., and M. Carver. 1986. Type-specimens of Hemiptera (Insecta) transferred from Macleay Museum, University of Sydney, to the Australian National Insect Collection, Canberra. *Proceedings of the Linnean Society of New South Wales* 108(4): 263–266.